

行政院國家科學委員會專題研究計畫 成果報告

不固定作業關係最佳化排程模式之研究(I)

計畫類別：個別型計畫

計畫編號：NSC91-2211-E-002-092-

執行期間：91年08月01日至92年07月31日

執行單位：國立臺灣大學土木工程學系暨研究所

計畫主持人：曾惠斌

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一、中文摘要

為達完工如期的目標，學理上發展出許多模擬專案進行的進度模式，如桿狀圖、平衡線圖、或網圖等。而這些進度控制模式中皆假設作業的施作順序是固定不變的，即假設無論在任何時間任何情況下，作業的關係都不會有所改變。然而工程實務上作業間施作順序卻未必固定不變，換言之，作業間除了存在固定的作業關係外，也存在不固定的作業關係。

隨著工程規模的擴大與複雜度提高，作業關係的變動情形更為頻繁與複雜，對於作業項目繁多的專案以人工方式修改也變得相當費時、費力與不容易，因此往往使進度表成為施工流程的紀錄，而無法作為進度控制與預警的工具，因此本研究擬針對營建工程專案以發展不固定作業關係之進度模式為目標，先釐清不固定作業關係之類型、作業關係變化條件、排序原則及排程限制條件等，再發展一模式以充分表達不固定作業關係之屬性與行為，並推演不固定作業關係變更之演算法。

關鍵詞：排程、不固定作業關係、物件導向

Abstract

The relations of the construction activities can be demonstrated by the fixed logic and the soft logic. The fixed logic provides only a logic sequence of the construction activities, on the other hands, with soft logic, which provides other possibilities of analyzing the activities. The

current network techniques presume that there is only one logical sequence of the activities in a project; therefore planners need to choose one particular logical sequence even if there is more than one solution, which is causing the time-consuming problem of schedule updating on soft logic sequencing. This paper discusses the factors that influence the sequencing of the soft logic and the heuristic sequencing principles. It develops algorithms incorporating with the heuristic sequencing principles to automatically identify the logical sequence of activities with soft logic that satisfies the given factors, and encapsulates the concept in a model with object-oriented paradigm.

Keywords: scheduling, soft logic, object-oriented

二、Problem Statements and Objectives緣由與目的

Current network techniques presume that there is one logic sequence of the activities. However, in reality, there is sometimes more than one possible sequence, which was termed "soft logic" by Tamimi and Diekmann in 1988 [2]. Current models do not differentiate these two types of logic; therefore, planners need to choose one particular logic sequence of activities based on some original assumptions. Therefore, the person in charge of updating schedule has to spend more time on re-determining the sequence of activities in the plans with necessarily alternating and reselecting sequence to satisfy the criteria manually to maintain a practicable program [1].

As the complexity of a construction project increases, the associated need for updating the schedule also increases, and the procedures become quite complex and time consuming. This creates problems when the planner is unable to update changes fast enough for the field personnel and schedule control. In this paper, the problem is said to be a soft logic problem.

The aim of this research is to ease the schedule updating process with soft logic sequencing, i.e., solving the aforementioned problem with the soft logic. Therefore, in order to capture the factors influencing the soft logic sequencing, this research has developed a model that differentiate soft logic from fixed logic and offer a planner assumptions of the soft logic. Furthermore, the model should be able to identify the sequencing of the soft logic, which satisfying the given factors as the heuristic sequencing principles. At the same time, the model will provide the planner information of early dates, late dates and the float of each activity, and identify project duration and critical path activities.

To achieve the objectives, it involves four steps in the procedure of this research. First of all, the discussion of the factors influencing the sequencing of soft logic and the heuristic sequencing principles. Secondly, the development of the algorithms incorporating with the heuristic sequencing principles to identify the logical sequence of activities that satisfy the given factors. Thirdly, it encapsulates the concept in a model, which differentiates soft logic from fixed logic called OERT with object-oriented paradigm. Finally, it implements the proposed model by MS Visual C++.

三、研究報告內容

This paper proposes a model called Object-oriented Evaluation and Review Technique (OERT), which utilize object-oriented modeling to deal with the soft logic problem. Figure 1 shows the key classess in OERT. The notification in this figure is based on the new standard Unified Modeling Language (UML). The class

“CProject” is the abstraction of projects and each activity is abstracted as class “CActivity”. A project consists of several activities and each activity has two types schedule logic, fixed and soft defined as noted earlier in this paper. Each activity has non or more underlying layer activities but has zero or only one upper layer activities. Each activity has zero or more interchangeable activities.

The factors influencing soft-logic sequencing are modeled as attributes and associations of class “CActivity.” Attribute “Priority” is a number by random assignment or according to the users’ preference to model the “predefined preference or consideration” on the logical sequence of this activity with other interchangeable activities. Attribute “NAOT” is to capture the “Number of Activities that can proceed at One Time” of the interchangeable set that this activity belongs to. Attributes “AS”, “AF”, “RD” are records of “Actual progress”. Factor “Fixed precedence activities” is captured by the “have fix logic with” association.”

There are 4 assumptions concerning OERT: 1) The precedence relationship of soft logic is based on the smallest fixed early start and the priority number. The priority number is given in advance by random assignment or according to the users’ preference; but if the activity has started, it will become the top priority. This assumption uses the smallest fixed early start to simulate the aforementioned “the activity which can be started shall start first” principle, and uses the priority number to simulate the other two aforementioned principles, “predefined preference or consideration” and “the activity in progress will continue to proceed with top priority.” 2) Soft logic only exists between activities having no underlying layer activities. 3) Each activity may have numerous interchangeable activities, but within each time section, each activity only has one soft precedence activity and one soft successive activity. 4) The precedence relationships, no matter fixed or soft, is presumed to be “Finish to Start” type.

As CPM, during the schedule-generating phase, the user subdivides the project into activities and assessing the duration at first, and then determining the schedule logic, but in OERT, the user no need to select one out of many possible sequences of the activities with soft logic. The user only needs to distinguish these activities from the activities with fixed logic by giving “interchangeable activities”, and gives the associated constrains, such as “NOAT” and “Priority”. OERT selects one out of many possible sequences of the activities with soft logic satisfying the associated constrains as well as gives the project duration, early and late dates, float time, and critical path automatically. During the updating period, with input of actual dates and while the external factors have been changed, such as the NAOT or interchangeable activities. OERT is able to rearrange the sequence automatically in order to satisfies the new given constrains, and provide information of the early and late dates, float time, and critical path to refer to the impact of logic changes on project completion date and critical path. Table 1, 2 show the different procedures of schedule-generating and schedule-updating between CPM and OERT.

Figure 2, detailing the calculation procedures of the OERT, which involve 8 algorithms. The data needed are the fixed precedence and successive activities, the interchangeable activities, the associated priority, NAOT, upper layer activity, underlying layer activities, original duration, actual start, actual finish and remain duration of each activity. Then the calculation starts from any activity and repeats these 8 algorithms till all the activities in the project are calculated.

四、Conclusions 結果與討論

Changes in network logic may cause significant overruns in project duration. These changes occur frequently in the networks that have soft logic. In order to keep the network up to date, many man-hours have to be spent when using current scheduling models. This

research has concluded the ideas of all the factors influencing soft-logic sequence and heuristic sequencing principles from which developing a incorporative algorithms to identify the logic sequence of activities with the soft logic and comply with the given factors, encapsulating the concept of a model with object-oriented paradigm, OERT. OERT system provide a method to differentiates soft logic from fixed logic, and it accommodates changes in actual and projected dates and in work capacities. Soft logic changes are updated immediately to reflect the impact on the project completion date and on the critical path of the project.

Moreover, by applying MS Visual C++ the proposed model provides a simplified schedule updating process in soft logic sequencing. The person, updating schedule no need to spend time re-determining whether the sequence of activities in the plan has alternatives and modifies it manually. With updating the changed factors, OERTSS is able to revise the associated sequences of the soft logic automatically and process fast enough for schedule control personnel. At the same time, it provides information of the early dates, late dates, the float for each activity, and identify project duration and critical path activities.

Future research could integrate this model with other control system such as the cost system. It provides the advantage to determine the impact on changing soft logic of the total cost and other control parameters. The concept of the models such as PERT or MCSA could be incorporated with OERTSS, soft logic as well as deterministic duration. The concepts presented by PLATFORM model can be incorporated with this model in order to ease the schedule updating both make it logical and reduce the construction duration. Furthermore, continuous research in the future may also consider the multiple-user objectives as part of the proposed ideas of SERSI, to develop algorithms to satisfy duration optimization, increasing network flexibility and improving resource profile, etc.

五、Reference 參考文獻

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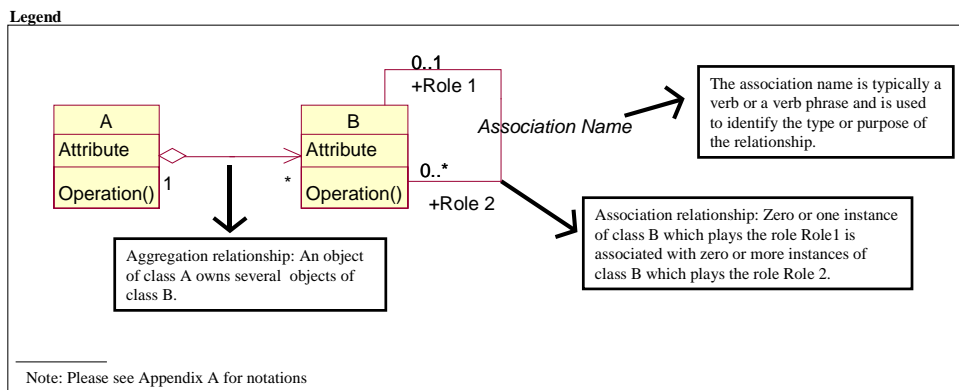
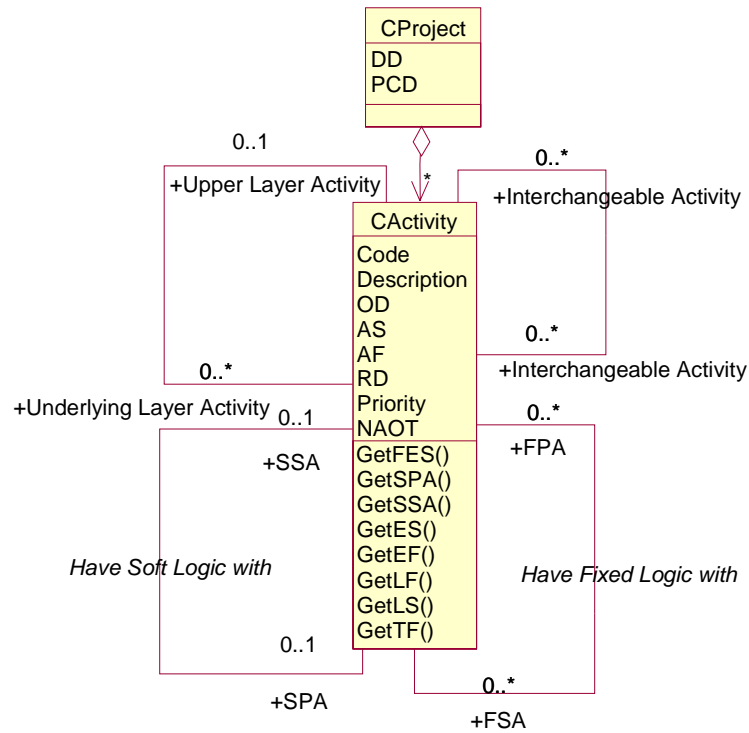


Figure 1: Key classes in OERT

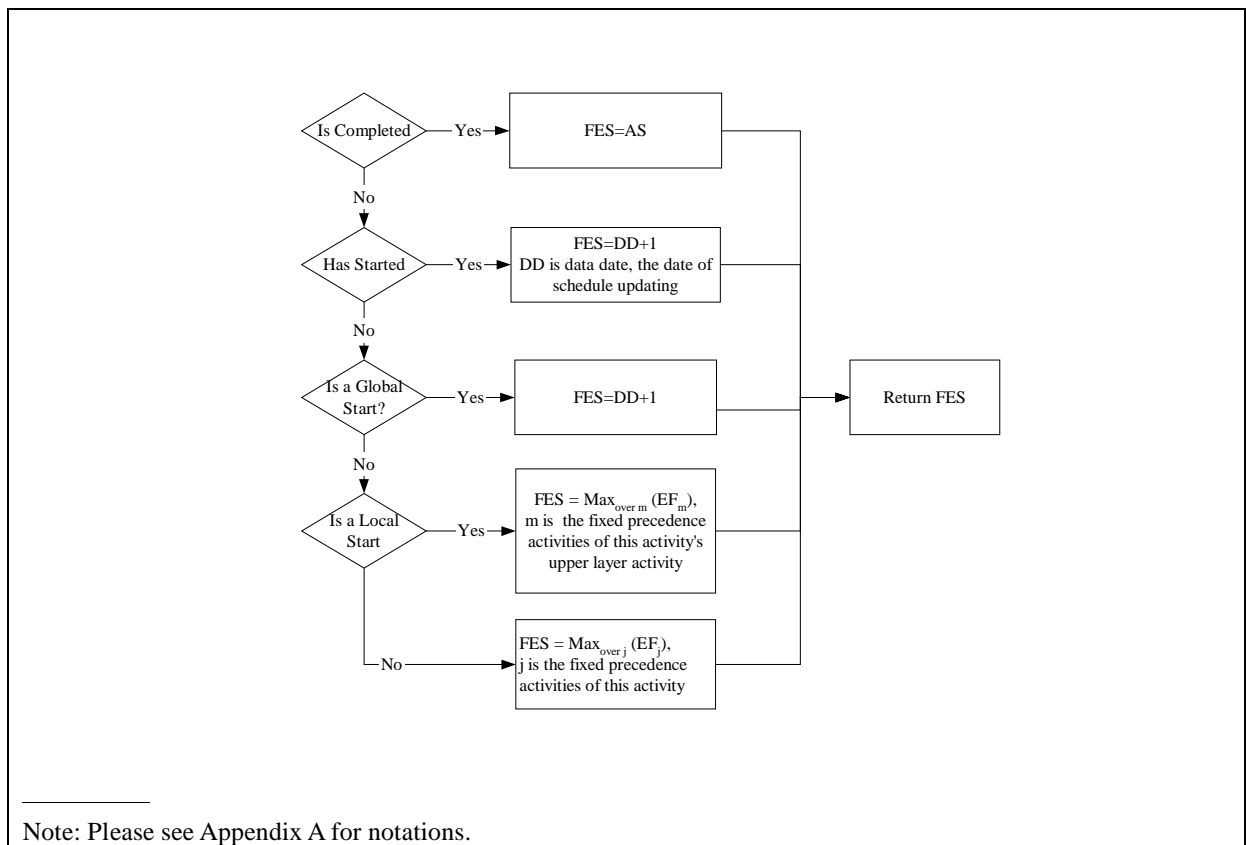


Figure 2: Calculation procedures of “To Calculate FES”

Table 1: Differences of schedule-generating procedures between CPM and OERT

Steps	CPM[1]	OERT
1	Defining the project into details of activities	Same as CPM
2	Assessing the durations of each activity.	Same as CPM
3	Determining a logic schedule, including choose one possible sequence out of many activities with soft logic to satisfy constrains.	Determining a logic schedule, need not to select any sequence out of activities with soft logic, and but simply distinguish soft logic from fixed logic by giving “interchangeable activities”, and gives the associated constrains, such as “NOAT” and “Priority”.
4	Utilizing the CPM algorithm to process the calculation to give early dates, late dates, the float of each activity, and identifying project duration and critical path activities.	Utilizing the OERT algorithm to identify a possible sequences of activities with soft logic that satisfies the given constrains, and to process the calculation to give early dates, late dates, the float for each activity, and to identify project duration and critical path activities.
5	Revising project duration and sequence logic to refine the schedule and complete the project on time. Including re-identifying a possible sequence of the activities with soft logic while taking consideration of the new constrains.	Revising project duration and constrains to refine the schedule and ideal project completion time. OERT able to revise the logic to satisfy the new given constrains.

Table 2: Differences of schedule-updating procedures between CPM and OERT

Steps	CPM[1]	OERT
1	Establishing the status of different various stage in activities: completed, in-progress, or postponed.	Same as CPM
2	Revising the duration of uncompleted construction activities.	Same as CPM
3	Revising logic sequence while taking into consideration of current constraints.	Revising constrains. OERT able to revise the logic sequence to satisfy constraints.

Appendix A: Terminology

AD	Actual duration
AF	Actual Finish
AS	Actual Start
CPM	Critical Path Method
DD	Data Date, the date of schedule updating
EF	Early Finish
ES	Early Start
FES	Fixed Early Start
FPA	Fixed Precedence Activities, the activities that must finished before one can start.
FSA	Fixed Successive Activities
LF	Late Finish
LS	Late Start
NAOT	The Number of Activities that can proceed at One Time, the limitation of total number of activities with soft logic that can be done at one time due to external factors, such as limited resources.
OD	Original Duration
PCD	Project Completion Date
Priority	A number by random assignment or according to the users' preference to model the "predefined preference or consideration" on the particular logical sequence of activities with soft logic chosen by the planner based on the assumption, preference, or consideration before the tasks start.
RD	Remaining Duration

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